Forest Health Protection
Pacific Southwest Region

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To: Forest Supervisor, Tahoe National Forest

Subject: Insect and disease evaluation of silvicultural certification stand 'Gold 14' and an off-site Jeffrey pine plantation (Report NE09-04)

At the request of Mark Brown, Forest Silviculturist, Tahoe National Forest, Danny Cluck, Forest Health Protection (FHP) Entomologist and Bill Woodruff, FHP Plant Pathologist, conducted a field evaluation of stand 'Gold 14' and a nearby two-acre Jeffrey pine plantation on June 22, 2009. The objective of the visit was to evaluate the current forest health conditions within the stand, discuss what influence these conditions have on stand management objectives and provide recommendations as appropriate. Mark Brown, who participated in the evaluation, will use this information to support the silvicultural prescriptions he is preparing to fulfill requirements for his certification as a silviculturist in Region 5.

STAND 'GOLD 14' (NE 1/4 , Sec. 22, T20N, R11E, Mt. Diablo Meridian)

Background

Gold 14 is located on the Yuba River Ranger District, Tahoe National Forest, 2 miles northeast of Union Flat Campground at an elevation of 6,200 feet. Precipitation for the site averages 60 - 70 inches per year. Gold 14 is a red fir mixed conifer type with red fir (*Abies magnifica*) the dominant species (approximately 60% of the overstory trees), sugar pine (*Pinus lambertiana*) (35%), white fir (*Abies concolor*) (4%), and Douglas-fir (*Pseudotsuga menziesii*) (1%). Canopy cover appeared to be approximately 70%. The understory is a distribution of the above species in all sizes. Many small understory sugar pine trees have been killed by or infected with white pine blister rust (*Cronartium ribicola*). S-type annosus root disease (*Heterobasidion annosum*) was found on true fir.

The current average basal area is 307 sq.ft./acre and the stand density index (SDI) is approximately 650. From observing the skid roads and stumps in the stand, it appears the stand was selectively logged 35 - 50 years ago. At that time, some large trees of all species

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were removed. Earlier logging history is not known.

The distribution of old growth red fir and sugar pine trees and stumps in Gold 14 suggest that this stand was once stocked with large, widely spaced red fir and sugar pine. The fire scars on stumps and old sugar pine (see Figure 1) indicate that fire burned this stand numerous times prior to modern-day fire suppression. These recurring underburns would have maintained an understory of very few trees. The logging conducted in the last century was not effective in checking the in-growth of red fir that exists today; resulting in overstocked conditions (see Figure 2).

Figure 1. Old fire scars on sugar pine

Figure 2. Red fir in-growth in Gold 14

The management objectives for this stand are: 1) retain most of the sugar pine trees and all trees over 30" dbh; 2) remove mostly true fir in the understory to reach SDI 400 or approximately 185 sq.ft./acre basal area; and, 3) retain 50% canopy cover. Radial clearing around large sugar pine will also occur.

Observations

The overall level of white pine blister rust (WPBR) in Gold 14 appears light-to-moderate. WPBR has infected many of the small-diameter (< 12" dbh) sugar pine. Many of these appear to have been girdled and killed by the WPBR in the last decade or so. Some were predisposed by WPBR to lethal attacks by mountain pine beetles (see Figure 3).

Figure 3. Mountain pine beetle galleries on SP

Figure 4. White pine blister rust flag on SP

Individual branches of a few of the large-diameter sugar pine have been killed by WPBR (see Figure 4). In the live, infected small-diameter sugar pine, WPBR is killing tops and branches, or girdling boles near the ground; making many of them incapable of growing into mature trees. At this time, only a few small-diameter sugar pine trees per acre, appear to be free of rust and capable of reaching maturity. Four *Ribes spp.* plants (alternate host to WPBR on pine) were examined and appeared to be free of *C. ribicola*.

Some true fir trees within the stand have been attacked by the fir engraver beetle (*Scolytus ventralis*) resulting in dead tops or whole tree mortality.

S-type annosus root disease was found infecting true fir in the Gold 14. The presence of this disease was confirmed by conks of *H. annosum* found in true fir stumps (see Figure 5). S-type annosus affects true fir, Douglas-fir and giant sequoia. The presence of slow-growing tops on many understory and intermediate true fir suggests that *H. annosum* is fairly widespread within the stand. Some or all of the fir trees killed by the fir engraver may have been weakened by *H. annosum* prior to beetle attack. No p-type (pine-type) annosus was found.

Figure 5. Annosus conk in true fir stump

True fir dwarf mistletoe (*Arceuthobium abietinum*) is presents at low levels within the stand. Dwarf mistletoe plants or brooms were observed on understory and overstory true fir trees and mistletoe cankers were seen on the trunks of older true fir trees. Branch flagging (i.e. dead branches) caused by cytospora canker (*Cytospora abietes*) and red fir dwarf mistletoe (*Arceuthobium abietinum f.sp. magnificae*) was observed on many red fir trees.

Discussion and Recommendations

Insect and disease-caused tree mortality is generally occurring at low levels in Gold 14. The exception is small-diameter (< 12" dbh) sugar pine which are being killed by WPBR, mountain pine beetle, or both. A few understory true fir, probably infected with *H. annosum*, have been killed by fir engraver. This low level of mortality is probably due to the location on a wetter north-facing slope. However, even trees on north slopes are susceptible to beetle mortality during extended dry periods, especially with overstocking.

The proposed thinning of the understory to approximately 185 sq.ft./acre basal area should improve the vigor of most trees in Gold 14. True fir trees, infected with *H. annosum*, will usually survive when not stressed by competing trees. This is because s-type *H. annosum* primarily decays the heartwood in the butt and roots of true fir trees; leaving the cambium unaffected. As a result, infected true fir trees with full crowns, when released from competition, often will grow new wood on the exterior of the bole faster than the disease decays interior wood. This increases the stability of the trees by effectively strengthening

the bole and roots. However, some mortality of infected trees should be expected regardless of stand density.

Another option for treating s-type root disease centers is the removal of all host trees. Small group selection removals could be utilized to clear annosus root disease centers of all s-type annosus host trees (true fir and Douglas-fir) prior to planting non-susceptible sugar pine seedlings. Rust resistant sugar pine seedlings are recommended in Gold 14 because of the presence of WPBR.

In addition to the proposed thinning in the understory to 185 sq.ft./acre basal area, circular clearing of trees less than 30" dbh from around selected large diameter sugar pine is planned. Trees and shrubs should be cleared to outside the drip-line a sufficient distance to free up moisture needed to keep the sugar pine vigorous during droughts. This clearing will also remove ladder fuel which can carry ground fire to the crowns of larger trees. To prevent ground fires from igniting sloughed bark and duff around the bases of the large sugar pine, it is recommended that the accumulated duff be raked away, down to mineral soil, two feet from the bole, and scattered. It has been demonstrated that sloughed bark and duff at the base of large conifers often burns slowly; creating sufficient heat to kill cambium and girdle (kill) trees. Raking treatments of this type will reduce fire injuries to the bole without negatively effecting tree health, vigor or increasing mortality.

In order to prevent *H. annosum* spores from infecting healthy conifer stumps and roots, it is recommended that a registered borate compound be applied to all freshly cut pine and true fir stumps >14" dbh. Borax has been proven effective in preventing stump infection by *H. annosum*. Since borate is a preventative treatment, treating stumps of infected true fir will not cure the disease.

Summary for Gold 14

When planning thinning treatments, it should be recognized that the target stand density is an average to be applied across the landscape and some variability may be desired. Individual high value trees, such as mature sugar pine, should benefit by having the stocking around them reduced to lower levels. In addition, when selecting trees for removal, preference should be given to trees infected with dwarf mistletoe, root disease, white pine blister rust and trees infested with bark beetles. Group selections could be utilized to clear annosus root disease pockets of true fir and Douglas-fir so that they can be planted with sugar pine, which is not a host to s-type annosus.

Jeffrey Pine Plantation (NE 1/4 , Sec. 11, T20N, R11E, Mt. Diablo Meridian)

Background

This two acre off-site Jeffrey pine plantation is located 4 miles northeast of Union Flat Campground at an elevation of 6800 feet. Jeffery pine seedlings were planted in 1980 on this lodgepole pine-red fir site. Seedling survival appears acceptable; but height growth is stunted and growth form is poor. Tree heights range from 4 to 12 feet. Deep snow and a short growing season are probably the reasons for the poor performance of these off-site Jeffrey pine seedlings. Soil conditions may also be a contributing factor.

It appears that a handful of these small Jeffrey pine per acre might grow to acceptable overstory trees. Most will remain stunted in the understory. Eventually, many will die as a result of successful bark beetle attack. Over time, native trees will eventually regenerate and return this plantation to its natural composition. Alternatively, managers could remove the off-site Jeffrey pine and plant site-appropriate seedlings as needed to maintain stocking. This would return the stand to its natural composition perhaps a century sooner.

Available funding

Forest Health Protection may be able to assist with funding for thinning and removing competing trees from overstocked areas within Gold 14 on a competitive basis. If you are interested in this funding please contact any of the Forest Health Protection staff for assistance in developing and submitting a proposal.

If you have any questions regarding this report and/or need additional information please contact Bill Woodruff at 530-252-6680 or Danny Cluck at 530-252-6431.

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Insect and Disease Information

Mountain pine beetle

The mountain pine beetle, *Dendroctonus ponderosae,* attacks the bole of ponderosa, lodgepole, sugar and western white pines larger than about 8 inches dbh. Extensive infestations have occurred in mature lodgepole pine forests. Group killing often occurs in mature forests and young overstocked stands of ponderosa, sugar and western white pines.

Evidence of Attack

The first sign of beetle-caused mortality is generally discolored foliage. The mountain pine beetle begins attacking most pine species on the lower 15 feet of the bole. Examination of infested trees usually reveals the presence of pitch tubes. Pitch tubes on successfully infested trees are pink to dark red masses of resin mixed with boring dust. Creamy, white pitch tubes indicate that the tree was able to "pitch out" the beetle and the attack was not successful. In addition to pitch tubes, successfully infested trees will have dry boring dust in the bark crevices and around the base of the tree. Attacking beetles carry the spores of blue-staining fungi which develop and spread throughout the sapwood interrupting the flow of water to the crown. The fungi also reduces the flow of pitch in the tree, thus aiding the beetles in overcoming the tree. The combined action of both beetles and fungi causes the needles to discolor and the tree to die.

Life Stages and Development

The beetle develops through four stages: egg, larva, pupa and adult. The life cycle of the mountain pine beetle varies considerably over its range. One generation per year is typical, with attacks occurring from late June through August. Two generations per year may develop in low elevation sugar pine. Females making their first attacks release aggregating pheromones. These pheromones attract males and other females until a mass attack overcomes the tree. The adults bore long, vertical, egg galleries and lay eggs in niches along the sides of the gallery. The larvae feed in mines perpendicular to the main gallery and construct small pupal cells at the end of these mines where they pupate and transform into adults.

Conditions Affecting Outbreaks

The food supply regulates populations of the beetle. In lodgepole pine, it appears that the beetles select larger trees with thick phloem, however the relationship between beetle populations and phloem thickness in other hosts has not been established. A copious pitch flow from the pines can prevent successful attack. The number of beetles, the characteristics of the tree, and the weather affect the tree's ability to produce enough resin to resist attack. Other factors affecting the abundance of the mountain pine beetle include nematodes, woodpeckers, and predaceous and parasitic insects. As stand susceptibility to the beetle increases because of age, overstocking, diseases or drought, the effectiveness of natural control decreases and pine mortality increases.

Fir Engraver

The fir engraver attacks red and white fir in California. Fir engraver adults and developing broods kill true firs by mining the cambium, phloem, and outer sapwood of the bole, thereby girdling the tree. Trees greater that 4" in diameter are attacked and often killed in a single season. Many trees, weakened through successive attacks, die slowly over a period of years. Others may survive attack as evidenced by old spike-topped fir and trees with individual branch mortality. Although many other species of bark beetles cannot develop successful broods without killing the tree, the fir engraver beetle is able to attack and establish broods when only a portion of the cambium area has been killed.

Evidence of Attack

Fir engravers bore entrance holes along the main stem, usually in areas that are > 4" in diameter. Reddish-brown or white boring dust may be seen along the trunk in bark crevices and in spider webs. Some pitch streamers may be indicative of fir engraver attacks; however, true firs are known to stream pitch for various reasons and there is not clear evidence that pitch streamers indicate subsequent tree mortality or successful attack. Resin canals and pockets in the cortex of the bark are part of the trees defense mechanism. Beetle galleries that contact these structures almost always fail to produce larval galleries as the adults invariably abandon the attack. Pitch tubes, often formed when bark beetles attack pine, are not produced on firs.

Adults excavate horizontal galleries that engrave the sapwood; the larval galleries extend at right angles along the grain. Attacks in the crown may girdle branches resulting in individual branch mortality or "flagging". Numerous attacks over part or the entire bole may kill the upper portion of the crown or the entire tree. A healthy tree can recover if sufficient areas of cambium remain and top-killed trees can produce new leaders. The fir engraver is frequently associated with the roundheaded fir borer and the fir flatheaded borer.

Life Stages and Development

In the summer, adults emerge and attack new host trees. The female enters the tree first followed by the male. Eggs are laid in niches on either side of the gallery. Adult beetles carry the brown staining fungi, *Trichosporium symbioticum*, into the tree that causes a yellowish-brown discoloration around the gallery. The larvae mine straight up and down, perpendicular to the egg gallery. Winter is commonly spent in the larval stage, with pupation occurring in early spring. In most locations, the fir engraver completes its life cycle in 1 year, however at higher elevations 2 years may be required.

Conditions Affecting Outbreaks

Fir engravers bore into any member of the host species on which they land but establish successful galleries only in those that have little or no resistance to attack. Populations of less aggressive species like fir engraver are likely to wax and wane in direct relationship to the stresses of their hosts. Drought conditions often result in widespread fir mortality; however, attempting to determine when outbreaks will occur is difficult. Lowered resistance of trees appears to be a contributing factor. Overstocking and the increased presence of fir on sites that were once occupied by pine species may also contribute to higher than normal levels of fir mortality. Several insect predators, parasites and woodpeckers are commonly associated with the fir engraver and may help in control of populations at endemic levels.

Annosus Root Disease

Heterobasidion annosum is a fungus that attacks a wide variety of woody plants. All western conifer species are susceptible. Madrone (*Arbutus menziesii*), and a few brush species (*Arctostaphylos spp.* and *Artemisia tridentata*) are occasional hosts. Other hardwood species are apparently not infected. The disease has been reported on all National Forests in California, with incidence particularly high on true fir in northern California, in the eastside pine type forests, and in southern California recreation areas.

Annosus root disease is one of the most important conifer diseases in Region 5. Current estimates are that the disease infests about 2 million acres of commercial forestland in California, resulting in an annual volume loss of 19 million cubic feet. Other potential impacts of the disease include: increased susceptibility of infected trees to attack by bark beetles, mortality of infected trees presently on the site, the loss of the site for future production, and depletion of vegetative cover and increased probability of tree failure and hazard in recreation areas.

During periods favorable to the fungus, fruiting bodies (conks) form in decayed stumps, under the bark of dead trees, or under the duff at the root collar. New infection centers are initiated when airborne spores produced by the conks land and grow on freshly cut stump surfaces. Infection in true fir may also occur through fire and mechanical wounds, or occasionally, through roots of stumps in the absence of surface colonization. From the infected stump surface, the fungus grows down into the roots and then spreads via root-to-root contact to adjacent live trees, resulting in the formation of large disease centers. These infection centers may continue to enlarge until they reach barriers, such as openings in the stand or groups of resistant plants. In pines, the fungus grows through root cambial tissue to the root crown where it girdles and kills the tree. In true fir and other non-resinous species, the fungus sometimes kills trees, but more frequently is confined to the heartwood and inner sapwood of the larger roots. It then eventually extends into the heartwood of the lower trunk and causes chronic decay and growth loss.

Heterobasidion annosum in western North America consists of two intersterility groups, or biological species, the 'S' group and the 'P' group. These two biological species of *H. annosum* have major differences in host specificity. All isolates of *H. annosum* from naturally infected ponderosa pine, Jeffrey pine, sugar pine, Coulter pine, incense cedar, western juniper, pinyon, and manzanita have, to date, been of the 'P' group. Isolates from true fir and giant sequoia have been of the "S" group. This host specificity is not apparent in isolates from stumps; with the 'S' group being recovered from both pine and true fir stumps. These data suggest that infection of host trees is specific, but saprophytic colonization of stumps is not. The fungus may survive in infected roots or stumps for many years. Young conifers established near these stumps often die shortly after their roots contact infected roots in the soil.

Dwarf Mistletoe

Dwarf mistletoes (Arceuthobium spp.) are parasitic, flowering plants that can only survive on living conifers in the Pinaceae. They obtain most of their nutrients and all of their water and minerals from their hosts.

Dwarf mistletoes spread by means of seed. In the fall the fruit ripen and fall from the aerial shoots. The seeds are forcibly discharged. The seed is covered with a sticky substance and adheres to whatever it contacts. When a seed lands in a host tree crown, it usually sticks to a needle or twig, where it remains throughout the winter. The following spring the seed germinates and penetrates the twig at the base of the needle. For the next 2-4 years, the parasite grows within

the host tissues, developing a root-like system within the inner bark and outer sapwood, and causing the twig or branch to swell. Aerial shoots then develop and bear seed in another 2-4 years.

Dispersal of dwarf mistletoe seeds is limited to the distance the seeds travel after being discharged. From overstory to understory, this is usually 20 to 60 feet, but wind may carry them as far as 100 feet from the source. A rule of thumb is that the seeds can travel a horizontal distance equal to the height of the highest plant in an infected tree. There is some evidence that long distance spread of dwarf mistletoe is occassionaly vectored by birds and animals.

Vertical spread within tree crowns of most dwarf mistletoes is limited to less than one foot per year because of foliage density. Because of the thin crowns of gray pine, however, the vertical rate of spread has been measured as being greater than 2 feet per year. This rate of spread equalled or exceeded the rate of height growth of infected trees.

Dwarf mistletoes are easy to identify because they are generally exposed to view within a tree's crown. Signs of infection include the yellow-green to orange mistletoe plants, basal cups on a branch or stem where the plants were attached and detached plants on the ground beneath an infected tree. Symptoms include spindle-shaped branch swellings, witches' brooms in the lower crown, and bole swellings.

White pine blister rust

White pine blister rust is caused by Cronartium ribicola an obligate parasite that attacks 5-needled pines and several species of Ribes spp. The fungus needs the two alternate hosts to survive, spending part of its life on 5-needled pines and the other on Ribes spp. The disease occurs throughout the range of sugar pine to the southern Sierra Nevada, but has not been reported further south. Infection of pines results in cankers on branches and main stems, branch mortality, top kill, and tree mortality.

Spores (aeciospores) produced by the fungus in the spring on pine bole or branch cankers are wind-disseminated to Ribes spp. where they infect the leaves. Spores (urediospores) produced in orange pustules on the underside of the leaves reinfect other Ribes spp. throughout the summer, resulting in an intensification of the rust. A telial spore stage forms on Ribes spp. leaves in the fall. Teliospores germinate in place to produce spores (sporida) which are wind-disseminated to pines and infect current year needles. Following infection, the fungus grows from the needle into the branch and forms a canker. After 2 or 3 years, spores are produced on the cankers and are spread to Ribes spp. to continue the cycle. Although blister rust may spread hundreds of miles from pines to Ribes spp., its spread from Ribes spp. back to pines is usually limited to a few hundred feet.

Branch cankers continue to enlarge as the fungus invades additional tissues and moves toward the bole. Branch cankers within 24 inches of the bole will eventually form bole cankers. Bole cankers result in girdling and death of the tree above the canker. Cankers that have margins more than 24 inches from the main bole are unlikely to reach the bole and only branch flagging will result.